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ABSTRACT
            The purpose of this paper is to discuss some of the
problems and prospects of applying production function or
input-output analysis to the process of schooling. The cognitive
aspect of schooling is discussed here and is restricted to those
aspects readily measured by achievement tests. It is argued that
education production function studies should rely less on large-scale
survey data; and that they should instead develop microdata on actual
processes, especially by means of the experimental identification of
production functions. Applied studies in educational production
functions can address two main categories of questions: (1) those
dealing with efficiency, and (2) those dealing with distribution. A
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INPUTS AND OUTPUTS

IN THE EDUCATIONAL PROCESS*

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I

(In which the author agrees with the reader that education may be viewed,
at least in part, as a deliberate process of production.)

I assume that the economists at this symposium would be willing to grant with

no further ado that education may be viewed, at least in part, as a deliberate

process of production, but for those to whom this viewpoint may be new I will

briefly explain the concepts and analogies from which it derives.

It is quite clear that many other things besides education are deliberately

produced. The farmer, for example, certainly intends to reap a crop when he

combines land, seed and labor under favorable conditions. He may of course use

these ingredients in varying amounts, and may also use fertilizers and machines.

Likewise, the manufacturer combines man-hours of certain labor skills with

machine-hours and materials of certain kinds, to produce the widgets his firm

sells on the market. The flows of services of people, materials and equipment

are called "inputs," and the resulting flow of the produced item is called the

"output." If all the inputs and the output are measurable, the relationship

between each possible combination of inputs and the resulting output can be

expressed as a mathematical function, which in this case is called a production

function.[1] In order for input-output relations to be described by such a function,

each combination of inputs must result in only one level of a particular kind of

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[1]Production functions are defined and discussed in all microeconomics texts.
For an excellent concise introduction, see Allen (1966).

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output, as is the case when the inputs are combined with technical efficiency, which means they are combined so as to result in the largest output possible with the technology employed, for given amounts of inputs. In ordinary economic analysis, market competition is regarded as ensuring that each producer is both technically and economically efficient by rewarding with profits those who are efficient, and with losses those who are not.

The purpose of this paper is to discuss some of the problems and prospects of applying this kind of production function or input-output analysis to the process of schooling. The cognitive aspect of schooling will be discussed here, to the disappointment of those who think that the affective is equally (or more) important, or that the affective cannot be separated from the cognitive. Furthermore, the cognitive aspects will be restricted to those readily measured by achievement tests. It is only indirectly, to the extent that "achievement" is related to future earnings, that this analysis approaches the subsequent "economic" outcomes, narrowly defined, of schooling--let alone effects of schools as socializing or social mobility agencies, or as detention homes where youngsters are cured of troublesome spontaneity and individuality. For this discussion to proceed, the reader need only agree that school people do arrange and combine various resources with the intention of teaching various cognitive skills (in, say, mathematics or language). With human and non-human resources as inputs, and achievement on specified tests as a measure of output, let us see how far we can go with educational production functions.

II

(Estimates of educational production functions reviewed, with a perhaps one-sided attention to their weaknesses.)

Attempts to identify educational production functions are now quite numerous, so I will not attempt to deal with each individually.[2] Nor will I single out one

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[2]The principal studies relevant to the following discussion include Bowles (1970), Burkhead et al. (1967), Hanushek (1968), Katzman (1968), Kiesling (1967),

or two for detailed analysis, for although some are better--indeed, much better--
than others, they are all sufficiently alike in concept and method to be subsumed
under one or more of the following general criticisms (with footnote references
to noteworthy exceptions). Most of the weaknesses I will mention are well known
to the various researchers, who in each case have done their best in the face of
these problems, not in ignorance of them.

In general, a model is postulated in which one or more measures of general
achievement (mathematics or verbal scores) is dependent on one or more sets of
independent variables (representing student, family or community, and school
characteristics). The specification of the model is usually as linear
additive,[3] which means that the individual effects of the independent variables
merely sum to produce a cumulative effect on the dependent variable. This implies
that the size of the effect of any particular variable is not influenced by the
presence or absence of other variables (collinearity aside), and that each
additional unit of a variable has equal impact on the dependent variable. These
implications are sufficiently implausible over any but a very narrow range of data
that the additive model should be retained only if, in spite of implausibility,
it yields powerful results. This it does not do. Its popularity is presumably
due more to its convenience than its congruence with reality.

Specification errors are also pervasive in the selection of both output and
input variables. In most studies so far, for example, the output variables

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and Thomas (1962). The Equality of Educational Opportunity survey (the "Coleman
Report") is usually regarded as a production function study, although it was not
explicitly designed as such (Coleman et al., 1966). In addition, the reader's
attention is directed to the innovative work of Henry M. Levin (1970). Reviews
of other studies and extensive bibliographies will be found in U. S. Department
of Health, Education, and Welfare, Do Teachers Make A Difference? (1970). A
survey of earlier work and related studies will be found in Lyle (1967).

[3]Kiesling (1967) has employed quadratic forms, and Hanushek (1967) reports
the log-log form he used gave little information gain over the additive model.

typically are summative measures of a few general abilities, usually arithmetic and/or reading or vocabulary skills.[4] These measures are less inappropriate for the elementary than for the high school years, where there can be no presumption that they measure the output of classes in music, art, business curricula, or industrial arts. Even where such general ability measures might be deemed appropriate, they typically are in terms of grade or class group mean scores rather than individual scores, with no attention being given to the variances or higher moments of the distributions from which the means are derived. Schooling, however, is a purposeful activity: we desire students to learn certain things. It is very important, therefore, to identify the extent to which distributions of educational outcomes differ from the normal (0,1) probability distribution, which is the distribution most appropriate for random events (outcomes). To the extent that elimination of "disadvantage" is of primary concern, for example, it can be argued that schooling is unsuccessful to the extent that the distribution of achievement approximates the normal, and successful to the extent that it approximates a J-shaped distribution with virtually no cases below the mode.[5]

Turning our attention to inputs, it should be noted that several production function studies have been based on survey data, such as those of the Coleman Report and Project TALENT surveys, which were not collected with production analysis in mind. Other studies have set out purposely to collect data for such analysis, but have relied primarily on what could be extracted from school records. As a result of these procedures, input variables have tended to be those which were readily available rather than those with a clear a priori theoretical or technical relevance to the output variables. It sometimes appears that a handy variable has been entered to "see if it makes a difference," rather than because

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[4]Katzman (1968) is one who uses other kinds of "outputs," such as school retention of students, as do Burkhead et al. (1967).

[5]Cf. Bloom (1968).

it was expected to make a difference. The discovery of statistically significant effects has required much post-hoc theorizing and imaginative constructs of "proxies."

In nearly every study, the average amount of each "school" input has been assumed to apply to each student. To the extent that this represents actual educational practice it is an important reason to expect background variables to account for more of the variance in achievement than will school variables, except when schools show large variance in input means. To the extent that it does not reflect actual practice it of course weakens the models, particularly with respect to the application of results to improve within-school allocations. Some studies have been handicapped by "school" input data which refers to entire districts instead of individual schools within internally heterogeneous districts.[6] In addition, it has been difficult if not impossible to deal adequately with the problems of pupil inter-school mobility and lack of longitudinal observations of achievement change ("value added") of individual students.[7]

As mentioned, most data have come from school accounts and reports or from sample surveys. These provide information on the stocks of certain quantities (such as books in the library, teachers with masters degrees, students of one or another type) but not on their actual utilization in an educational process. Reliance on such data is a serious shortcoming of most educational production function studies, for it is the services of productive units, not the units themselves, which are factors of production.[8] Since there are many possible ways in which educational resources can be combined, and since schools are so frequently accused of inefficiency, the estimation of meaningful production functions

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[6]This is but one of many criticisms leveled against the Coleman Report in the useful articles by Bowles and Levin (1968a, b).

[7]Cf. Bowles (1970) and the comments following the Bowles paper by John Hause.

[8]Cf. Robinson (1969), 19.

depends on the gathering and incorporation of new data on the actual utilization of productive inpuls.

III

(Further comments on omissions from production function studies, with specific reference to the allocation of time and to the individual as producer, concluding with the remark that schooling is a process which can only influence or augment the production of achievement by individuals.)

To measure the actual utilization of the various resources means no more than to measure the _time_ in which they are employed in various ways. In a fundamental sense, allocation of resources (human or material) is allocation of time.[9] It is as important to know how much time students spend in the library, and what they do while they are in it, as to know how many books are on the shelves. We cannot develop useful technical knowledge of how measurable outcomes of schooling are produced until we know how much time is spent on each activity, with what materials, and by what students.

The allocation of time has for the most part been omitted from production function studies, but is the most important kind of allocation for many school personnel.[10] The making of the annual money budget is an important event for every school board and superintendent (and teacher organization!), but is not logically more important than the (usually subsequent) making of time budgets. Expenditures on material and human resources are for the purpose of acquiring control over the services of the resources, but a record of such outlays does not show how the services so acquired were actually used. Time budgets for actual employment of the various services are determined for the most part by principals, in the making of class schedules, and by teachers, in the selection of class activities.

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[9] See the already classic article on allocation of time by Becker (1965). A less technical, and highly entertaining, discussion of the allocation of time is that of Linder (1970).

[10] See Thomas (1971, forthcoming) for a discussion of the allocation of time in schools.

There is some recent evidence of increased recognition that there may be ways
of allocating time which are preferable to the traditional school schedule. The
considerable talk about, and the few scattered attempts to operate year-round
schools reflect efforts to increase production by using a larger fraction of alread
available time of school plant and equipment, along with additional amounts of
teacher time. Similarly, the introduction of modular scheduling in hundreds of
schools may be seen as an attempt to rationalize the allocation of class time in
accord with beliefs about the conditions of learning: fine and practical arts
and science classes are given more time for set up and clean up per meeting, with
perhaps fewer meetings, while other classes, such as language "labs," may be
shortened. At another level, there are criticisms of the total years of an
individual's life allocated to schooling: thus in his "Great Training Robbery"
Ivar Berg argues that the use of diplomas as job screening devices can result in
exclusion of the competent but less educated and in some workers having spent
more years in school than can reasonably be justified in terms of their job levels
or career aspirations.[11] Similarly, the allocation of time between schooling
and alternative experiences is coming under increased scrutiny, as exemplified
by a recent Carnegie Commission report, "Less Time, More Options."[12] These
matters of the actual or alternative allocations of time could be usefully
incorporated into school production studies.

Another matter of great importance, also ignored in most school production
work so far, is that schooling can be approached from the individual decision-
making point of view--in a way not possible in the manufacturing or agricultural

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[11]Berg (1970); see also Kuhn (1970).

[12]Carnegie Commission on Higher Education (1970). The Carnegie study refers
primarily to higher education. An earlier discussion, including the secondary
level of education, is that by Bowman (1967).

production processes. Educators may organize schools and plan lessons according to implicit or explicit beliefs about educational production functions, but actual outcomes in every case depend also on the implicit or explicit decisions to participate made by each student involved in the schooling process. To the student school may be less important than some other activities, as immortalized in the statement attributed to Mark Twain that "I never let my schooling interfere with my education." That lack of schooling is not an insurmountable handicap for some persons is highlighted by the phrase "a self-made man," often used to refer to a man whose achievement was attained without benefit of much or any formal schooling. Indeed, the literal meaning of the words suggests that the person produced himself. Perhaps schooling should be regarded as less analogous to manufacturing than to agriculture. For in agriculture the purpose is to direct or augment a process of growth which would occur to some extent on its own. Likewise, each individual would learn to some extent on his own; the purpose of instruction is to accelerate learning, and to direct it in ways deemed good by educators and by the public whose agents they are intended to be.

Thus the individual, whether in or out of school, may be viewed as a producer of learning and achievement. Each individual has his own productive function, in which the rate at which he produces gains in achievement--whether measured in the marketplace or on objective tests--is determined by his general ability, his relevant prior achievement, the time he devotes to such production, and the use of other resources he either purchases or has made available to him.[13] The last category, "purchased" resources which come from outside the individual, is conceptually a very broad one which could include food and health care, books and

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[13]"Individual" production functions of this type have been employed by Becker (1967) and Ben-Porath (1967). It may be desirable to include consideration of possible "depreciation" of the individual's human capital: see Ben-Porath.

teacher time, and, certainly for young persons, parental time. What proportions of the various purchased resources, individual abilities, and prior learnings are most productive of achievement, and which marginal changes have the largest effects, will presumably depend on the kind of achievement to be measured. When students enter the social situations of school or classroom they do not cease being individuals; more especially, for the purposes of this paper, they do not cease being individual producers, and the goal of schooling is in general to increase or direct student production of learning.

Thus schooling should be regarded as a process designed to induce, influence, or augment individual activities with respect to the production of human resources. What the individual invests (or does not invest) in the process is a stream of services from his own initial or accumulated stock of human resources-- in the form of talent, skill, knowledge, or ability. If we assume individuals do but one thing at a time, we can use time as a measure of the share of each student's resources devoted to such production. What the school invests are purchased resources, both physical and human, and the opportunity for students to use them. Opportunity is here measured as the time the student has made available by the school with a share of the hired resources. Obviously, a student need not make use of the resource time made available to him, as when he is truant or daydreams in class. These cases, in which the student does not care to allocate his time as the school would have him do, are often called "motivation" problems. On the other hand, the school may not make accessible enough resource time--as when there are too few books to go around, or when the teacher moves on to a new topic before the slower students have mastered the material or skills. Inaccessibility to resources can take more subtle forms as well. Books with too difficult a vocabulary, for example, or teachers who speak a different language may not be accessible to students even if supplied in abundance.

IV

(Where, in general form, the author's remedy for the above weaknesses is prescribed.)

Having thus far catalogued only weaknesses and omissions from educational production studies, the impression may have been created that I consider the production function approach to have little merit. The contrary is true. If the premise is accepted that the effects of schooling are or can be non-random, then it ought to be possible to discover the systematic relations which obtain between the inputs and outputs of the process. The problem is one of definition and measurement, and of the proper level of investigation. I believe that more fruitful results will be obtained by temporarily setting aside the large-scale econometric analyses of aggregate data in favor of micro-level studies and the experimental identification of educational production functions.

In general, education production studies so far have found a number of background and school correlates of some mean achievement scores, but at a level of aggregation which allows few inferences about specific educational practices. The reason for this is that studies which aggregate over different curricula and instructional technologies lose power to aid decision-making with respect to particular curricula and technologies in proportion to the level of aggregat'on. The same is true in general economics, where, to take a familiar example of large-scale aggregation, Cobb-Douglas estimates of the relative factor proportions in United States industry are of no use to the individual businessman who must decide how best to make his widgets.

But businessmen and farmers have been directly aided by micro-level production function studies. Many such studies have dealt experimentally with particular products and processes, and have resulted in estimates of marginal productivities, marginal rates of substitution, and other indicators with which optimizing

decisions can be made.[14] In exactly the same way, economic analysis can undoubtedly help improve the production of education if production function studies are brought down to the micro-level where the choices between product, levels of output and processes are made.

At least one recent study (Hanushek, 1970b) has attempted to move in the direction indicated here by collecting data on achievement gains and the characteristics of teachers associated with particular students in one school district. Again, however, the study relies primarily on school inputs measured in accounting terms rather than in terms of utilization. Being based on actual school practice, this study (and also the ones referred to previously) is limited by the fact that such practice cannot be assumed technically efficient with respect to the input-output relations of the model. Nor is the distribution of achievement analyzed as an aspect of output. In sum, despite the recognition of the need for micro-analysis explicit in this study, it is apparent that it is not sufficient to continue using the procedures of previous studies, even on a smaller scale. New approaches are needed.

One way to advance our knowledge and our ability to improve schooling is to turn from the examination of school practice to the experimental identification of production relationships. A sufficient number of such experimental studies might provide a basis not only for improving the efficiency of educational production but for rationalizing the distribution of achievement, especially achievement of the basic learning skills upon which later learning both in school and on the job are presumably founded. Such experiments must include:

1) Clearly defined outputs and inputs.
2) Specification of the technology, and
3) Assurance of technical efficiency.

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[14]Examples of such studies will be found in Heary and Dillon (1961) and Davies (1954).

Condition one, with the present state of educational measurement, will limit choice of outputs to a fairly narrow range of cognitive skills and affective outcomes. This limitation, however, is a practical, not a conceptual one. Condition two must be understood in its broad sense, in which technology is not merely hardware of various kinds, but organizational and instructional procedures as well.[15] Condition three is met largely through exercising care in the conduct of experiments, and is one of the reasons for preferring experimental to naturalistic settings.

V

(Which may be skipped by those familiar with mastery learning.)

I must now make a digression to introduce the concept of learning for mastery. I suppose that the educationists at this symposium would not blink at the mention of "mastery learning," but for those to whom the concept may be new I will offer a brief description.

Mastery learning is a reformulation and sharpening of several concepts and procedures, most of which are by no means new.[16] It assumes that schooling is, or should be, a purposeful activity in which it is desired that students learn certain things. Mastery learning is a strategy, or, in economic terms, a technology, which enables a school to ensure that all, or very near all, of its students do master those "certain things." The essential elements of this technology are:

1) Stated behavioral objectives. These are the certain things students are intended to learn, that is, learning tasks which are to be mastered.

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[15]See Hirsch (1969), 36.

[16]See, for example, the description of the "Winnetka plan" in Washburne (1926). Recent development of mastery learning has its origin in the work of Carroll (1963) who, it should be noted, employs the concept of the production function. See also Bloom (1968) and Block (1971), the latter containing an extensive annotated bibliography.

2) Formative tests of each student's relevant prior achievement before instruction begins, and of his progress toward the current objectives. Such tests are for informational purposes, not for assigning grades.

3) Diagnosis of the deficiencies of each student with respect to the objective behaviors, based on the formative tests.

4) Instructional sessions, which may include group and individual instruction.

5) Individual (sometimes paired or group) review and remedial work, based on the diagnoses.

6) In hierarchical subjects, mastery of the logically prior before introduction of dependent material.

7) Criterion performance levels. These are defined as proportions correct on standardized tests of the objective behaviors. For example, if the objective is identification of the antecedents of pronouns, and the criterion performance is, say, 75 per cent, then all students will receive such instruction and review work as needed until all can get 75 per cent correct on a standardized test of that skill. Scores higher than the criterion performance levels represent "overlearning." Ordinarily, of course, we would expect that by the time slower students were able to get 75 per cent correct, brighter pupils would be "overlearning" and attaining higher scores. For experimental purposes, it is possible (at least partially) to control against such overlearning by giving the faster students the next lesson in a sequence, by assigning unrelated tasks, or simply by excusing the student, as soon as he can demonstrate achievement of the criterion performance level.

Mastery learning is not necessarily the best approach for teaching all things; in particular, it seems inappropriate for courses whose objectives are expressed in such terms as "developing an appreciation of . . . ," or "instilling respect for . . . ." But many courses have simpler goals: many aim to teach particular and often quite practical skills. Some of these skills, such as basic word

recognition, comprehension, and arithmetic skills, are the essential foundations

of most later learning,[17] and even of learning from many non-school experiences.

These basic skills are amenable to the mastery learning strategy. At any rate,

mastery learning is not introduced here as an instructional panacea but as an

investigatory tool in the analysis of educational production relationships. How

mastery learning can serve this purpose will next be explained.

VI

(In which mastery learning is related to the requirements of production
functions.)

The ability of the mastery learning strategy to produce nearly uniform between-

student criterion performance in various subject areas has been conclusively

demonstrated in numerous studies,[18] but the implications of this property for the

economic micro-analysis of instruction have not yet been explored. By using the

mastery learning approach it is possible to arrange and define the conditions of

school learning so that most students master specified skills at given levels of

performance, a model which closely parallels the economic one of a firm which can

produce a uniform product at various levels of output. The elements of such a

model of school learning can be experimentally manipulated to elicit production

information and to shed light on the relation between the production functions of

schools and those of individual students. In production terms, one such model

could be specified as follows:

1) The uniform kind of output produced would be mastery by all (or nearly all)

students of the defined skills (objectives) of a particular course or subject area.

2) The level of output would be the criterion performance level, as defined

above.

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[17]Cf. Bloom (1964).

[18]See Block (1970, 1971).

3) The technology of production would be the mastery learning technology, fully described for each particular estimation problem.

4) Each student's own resources would consist principally of his allocable time, with a quality or value dimension measurable as a composite of his general I.Q. and attainment of relevant prior skills.

5) The school resources would be the human and physical components called for in the particular configuration of mastery learning being employed. Use of these would be measured as time spent by each student with the components.

Readers familiar with economics should have no difficulty in visualizing the production surface expected to result from experiments in which (a) students of various initial resource endowments work to any given performance level and, in so doing, use various amounts of school resources, and (b) the analysis is repeated for several different performance (output) levels. Students representing a range of initial endowments would be randomly assigned to at least three performance level groups. For each student the amount of time spent with school resources in working to the assigned criterion performance level would be measured. From the function fitted to such a production surface, the marginal productivities and elasticities of substitution of student and school resources can be derived. Cost comparisons could be made for the achievement of various performance levels.

Similar experiments could be performed to compare different technologies, that is: different mixes of school human and physical resources; different teaching methods; different media combinations. Cost comparisons can be made also in a sequential analysis in which stage II learning may depend on stage I input-output alternatives. It should be emphasized that such experiments need not be restricted to the kinds of activities and range of variables currently found in most school practice. A sufficient number of such experiments could throw much light on the actual production of educational outcomes. The effect of different

configurations of school human and physical resources on the rate of learning by students with different composite initial endowments could be analyzed to find the elasticity of substitution between kinds of teachers, between teachers and physical capital, and between school and student resources.

VII

(The paper is concluded and some implications sketched.)

In this paper I have argued that education production function studies should rely less on large-scale survey data and instead should develop micro-data on actual processes, especially by means of the experimental identification of production functions. In addition, I have illustrated how one instructional technology might lend itself to this purpose, and how a few such experiments might be performed. The attempt to identify educational production functions is essentially an exercise in applied economics. As such, the information which results will be examined by various practitioners for its normative implications. The information itself, however, will be positive, that is, scientific. Applied studies in educational production functions can address two main categories of questions: those dealing with efficiency, and those dealing with distribution.[19]

The analysis of the distribution of education is, baldly stated, concerned with "who gets what." The distributions of, say, total years of schooling or of college atten ce have been amply studied, and some attention has been given to the distribution of school resources among schools. The distributions of students among curricula and of school resources among students within schools have received less attention. These distributions, however, are all on the input side. Equally important, from the standpoint of investigation into the production of particular cognitive outcomes, is analysis of the distribution of achievement

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[19]Distribution is used here in reference to educational achievement, not to the distribution of the product between the owners of the factors of production.

among students in a school or class. Whatever combination of ingredients produces school achievement also produces some distribution of that achievement: there is no reason to assume that such distributions will always have the familiar shape of a normal curve. For example, an innovation which raised mean scores only a little, but which succeeded in eliminating failing grades, would have an important distributional effect. Thus educational production function analysis may quite properly include comparison of the achievement distribution effects of alternative instructional strategies and resource combinations, at the class or subject level, and of alternative curricula, at the institutional level. The subsequent impact of different distributions of achievement upon later student achievement or decisions would also be opened to investigation.

Much of production analysis in theoretical economics is devoted to developing the decision rules for economic efficiency under the assumption that the locus of technically efficient combinations is known. In schooling, on the other hand, there is much room for the application of economics in locating technically efficient resource combinations. For example, it is clear that bright students are generally more efficient learners than dull students, but are there technologies which can increase the efficiency of dull students?[20] Or, within a single technology, how does productivity vary with different student characteristics and amounts of school resources? Again, some students are handicapped with respect to school achievement by cultural attributes different from those assumed by the school. With the same achievement as a goal, what approaches and techniques best

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[20]The possibility should be noted that schooling and ability may interact in favor of the more able. This would satisfy the apparent theoretical necessity (when returns to schooling are measured in monetary terms alone) that education give higher absolute marginal returns to the more able, in order for continued schooling to maintain a favorable rate of return despite the higher foregone earnings of the more able. Again, if schooling and ability are found to interact in favor of the more able, is that an artifact of the overrepresentation of the scholastically able in the control of schooling?

produce cross-cultural learning? Finally, recognition of the distribution of achievement as an outcome of schooling allows investigation of the relative effectiveness of various school technologies in producing distributions of the desired shape.

The answers to these kinds of questions, I believe, will contribute greatly to our ability to improve schooling and the allocation of resources to and within schools--whether our goal is to remodel within the traditional structure of schools or to take advantage of existing and developing alternatives to formal schooling.

REFERENCES

Allen, R. G. D. <u>Mathematical Economics</u>. 2nd ed. New York: St. Martins Press, 1966.

Becker, Gary S. <u>Human Capital and the Personal Distribution of Income: An Analytical Approach</u>. W. S. Woytinsky Lecture No. 1. Ann Arbor: Institute of Public Administration and Department of Economics, The University of Michigan, 1967.

Becker, Gary S. "A Theory of the Allocation of Time," <u>The Economic Journal</u>, LXXV (September, 1965), 493-517.

Ben-Porath, Yoram. "The Production of Human Capital and the Life Cycle of Earnings," <u>Journal of Political Economy</u>, LXXV, No. 4 (August, 1967, Part I), 352-64.

Berg, Ivar. <u>Education and Jobs: The Great Training Robbery</u>. New York: Praeger, 1970.

Block, James H. "The Effects of Various Levels of Performance on Selected Cognitive, Affective, and Time Variables." Unpublished Ph.D. dissertation, Department of Education, University of Chicago, 1970.

Block, James H. (ed.). <u>Mastery Learning: Theory and Practice</u>. New York: Holt, Rinehart and Winston, Inc., 1971.

Bloom, Benjamin S. <u>Stability and Change in Human Characteristics</u>. New York: John Wiley and Sons, Inc., 1964.

Bloom, Benjamin S. "Learning for Mastery," <u>Evaluation Comment</u> (U.C.L.A.-C.S.E.I.P.), Vol. 1, No. 2 (May, 1968).

Bowles, Samuel S. "Towards an Educational Production Function," in W. Lee Hansen (ed.), <u>Education, Income, and Human Capital</u>. New York: National Bureau of Economic Research (distributed by Columbia University Press), 1970.

Bowles, Samuel S., and Levin, Henry M. "The Determinants of Scholastic Achievement: An Appraisal of Some Recent Findings," <u>Journal of Human Resources</u>, Vol. 3, No. 1 (Winter, 1968a), 3-24.

Bowles, Samuel S., and Levin, Henry M. "More on Multicollinearity and the Effectiveness of Schools," <u>Journal of Human Resources</u>, Vol. 3, No. 3 (Summer, 1968b), 393-400.

Bowman, Mary Jean. "Decisions for Vocational Education: An Economist's View." Paper prepared for the symposium on Vocational-Technical Education, Prospectus for Change, Boston, Massachusetts, November 27-28, 1967.

Burkhead, Jesse, Fox, Thomas G., and Holland, John W. <u>Input and Output in Large-City High Schools</u>, Education in Large Cities Series. Syracuse: Syracuse University Press, 1967.

Carnegie Commission on Higher Education. Less Time, More Options. Fifth interim
    report. Hightstown, N. J.: McGraw-Hill Book Company, 1970.

Carroll, John. "A Model of School Learning," Teachers College Record, 64 (1963),
    723-33.

Coleman, James S. et al. Equality of Educational Opportunity. U. S. Department
    of Health, Education, and Welfare. Washington, D. C.: U. S. Government
    Printing Office, 1966.

Davies, Owen L. (ed.). The Design and Analysis of Industrial Experiments. London:
    Oliver and Boyd, 1954.

Hansen, W. Lee (ed.). Education, Income, and Human Capital. New York: National
    Bureau of Economic Research (distributed by Columbia University Press), 1970.

Hanushek, Eric. "The Education of Negroes and Whites." Ph.D. dissertation,
    Massachusetts Institute of Technology, 1968.

Hanushek, Eric. "The Production of Education, Teacher Quality, and Efficiency."
    Do Teachers Make a Difference? U. S. Department of Health, Education, and
    Welfare, 1970a.

Hanushek, Eric. "Teacher Characteristics and Gains in Student Achievement:
    Estimation Using Micro-Data." Paper presented at AEA meeting in Detroit,
    December, 1970b. (To be published in Papers and Proceedings of the Annual
    Meeting of the American Economic Association, May, 1971.)

Heady, Earl O., and Dillon, John L. Agricultural Production Functions. Ames:
    Iowa State University Press, 1961.

Hirsch, Werner Z. "Technological Progress and Microeconomic Theory," The American
    Economic Review, LIX (May, 1969), 36-43.

Katzman, Martin T. "Distribution and Production in a Big City Elementary School
    System," Yale Economic Essays, Vol. 8, No. 1 (Spring, 1968), 201-56.

Kiesling, Herbert J. "Measuring a Local Government Service: A Study of School
    Districts in New York State," Review of Economics and Statistics, Vol. 49,
    No. 3 (August, 1967), 356-67.

Kuhn, James W. "Would Horatio Alger Need a Degree?" Saturday Review, December 19,
    1970, 54ff.

Levin, Henry M. "A New Model of School Effectiveness." Do Teachers Make a
    Difference? U. S. Department of Health, Education, and Welfare, 1970.

Linder, Staffan B. The Harried Leisure Class. New York: Columbia University
    Press, 1970.

Lyle, Jerolyn R. "Research on Achievement Determinants in Educational Systems:
    A Survey," Socio-Economic Planning Sciences, 1 (1967), 143-55.

Robinson, Joan. The Economics of Imperfect Competition. London: Macmillan, 2nd ed., 1969.

Thomas, J. Alan. "Efficiency in Education: A Study of the Relationship Between Selected Variables and Test Scores in a Sample of United States High Schools." Unpublished Ph.D. dissertation, Stanford University; University Microfilms, Ltd., Ann Arbor, Michigan, 1962.

Thomas, J. Alan. The Productive School. New York: John Wiley and Sons, 1971 (forthcoming).

U. S. Department of Health, Education, and Welfare. Office of Education, Bureau of Educational Personnel Development. Do Teachers Make a Difference? A Report on Recent Research on Pupil Achievement. Washington, D. C.: Government Printing Office, 1970.

Washburne, Carleton. A Survey of the Winnetka Public Schools. Bloomington, Ill.: Public School Publishing Company, 1926.